AN ASSESSMENT OF PESTICIDE RESEARCH PROJECTS FUNDED BY THE MINISTRY OF THE ENVIRONMENT THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1976–1977

Ontario

Ministry of the Environment

The Honourable
George A. Kerr, Q.C.,
Minister

K.H. Sharpe,
Deputy Minister

AN ASSESSMENT OF

PESTICIDE RESEARCH PROJECTS

FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1976 - 1977

The Honourable

George A. Kerr, Q.C.,

Minister

K. H. Sharpe,

Deputy Minister .

PESTICIDES ADVISORY COMMITTEE

D. N. Huntley, B.S.A., M.S.A., Ph.D., LL.D.
Chairman

G. S. Cooper, B.A., B.Sc., M.Sc., Ph.D.
Vice Chairman

* J. R. Carrow, B.Sc. F., M.Sc., Ph.D.

C. D. Fowle, B.A., M.A., Ph.D.

R. Frank, B.Sc., M.S.A., Ph.D.

D. H. Harding, M.D., D.A.B. Path.

C. R. Harris, B.A., M.A., Ph.D.

J. C. Ingratta, B.S.A.

P. M. Lindley, B.S.A.

F. L. McEwen, B.Sc., M.Sc., Ph.D.

E. F. Muir, B.S.A.

G. R. Stephenson, B.Sc., M.Sc., Ph.D.

G. J. Stopps, M.B., B.S.

F. C. Taylor

K. B. Turner, B.Sc.F., M.Sc.F. (deceased)

A. R. Chisholm, P.Ag.
Executive Secretary to the Committee

* Succeeded the late K. B. Turner.

TABLE OF CONTENTS

RESEARCH PROJECTS FUNDED THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1976-77

I. SUMMARY

1) In 1976-77 the Ontario Pesticides Advisory Committee continued a program for funding research established in 1973. The objectives of the program are:

   a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   b) To determine potential environmental hazards with pesticides currently in use.

   c) To reduce pesticide input into the environment.

2) Twenty-seven applications for research grants, totalling $376,806 were received.

3) The total value of research grants awarded was $148,172. The average value/grant was $7,798 with a range of $3,000 to $19,360.

4) Two grants totalling $9,000 were awarded for studies on development of alternative pesticides for control of insect pests.

5) Eight grants totalling $64,248 were allocated to studies on the persistence and fate of pesticides in the environment and on potential environmental hazards to non-target organisms of pesticides currently in use.

6) Nine grants totalling $74,924 were awarded for studies aimed at reducing pesticide input into the environment without loss of effective pest control.

7) The Pesticides Advisory Committee is very satisfied with research progress made in 1976-77 and in preceding years. It recognizes that with the limited funds available the program of grants can be expected only to act as a catalyst in stimulating research in the broad areas indicated in the Committee's Guidelines and for which there is still an urgent requirement.

II. RECOMMENDATIONS

The Pesticides Advisory Committee recommends that:

1) The Ministry of the Environment continue the program of grants to encourage pesticide research.

2) The programs continue to be supervised by the Pesticides Advisory Committee following the guidelines developed over the past four years.

3) Funds in the amount of $225,000 be made available for the program in 1978-79.

III. REVIEW OF THE RESEARCH PROGRAM

In 1973 the Ministry of the Environment allocated funds to the Ontario Pesticides Advisory Committee to sponsor pesticide research. Results obtained to date (OPAC, 1974b, 1975a, 1976) have encouraged the Advisory Committee to recommend that the research program be continued under its supervision. The Committee is gratified that these recommendations have been accepted and that the Ministry has seen fit to increase the research budget from $100,000 in 1973-74 to $150,000/annum in 1976-77.

Initially the Advisory Committee developed terms of reference to govern the awarding of research grants based on three objectives, i.e. the need to find suitable replacements for pesticides deemed hazardous and restricted in use in Ontario; the need to determine if pesticides presently in use pose any serious environmental hazard; and the need to develop more effective approaches to pest control leading to a reduction in pesticide input into the environment. The "Call for Grant Requests" (Appendix I) based on these objectives, invited research proposals for studies on: 1) development, leading to registration, of environmentally acceptable pesticides, especially for control of biting flies and pests of agricultural crops (Objective 1); 2) the persistence, fate, and biological significance of residues of pesticides or mixtures of pesticides in the environment (Objective 2); and 3) economic thresholds of pests, improved pesticide application and pest monitoring techniques, and alternative non-chemical methods of control (Objective 3). Invitations for applications for grants were distributed widely in January 1976 to personnel in Ontario in universities, industry, and government (copies of the mailing list are available on request), with the deadline for receipt of applications being February 27, 1976.

Twenty-six applications were received for a total of $372,806. Twenty-five applications were received from universities (Guelph - 11, Western Ontario - 4, Toronto -3, York - 3, Brock, Queen's, Waterloo and Wilfred Laurier - 1 each), and one from a research foundation. No applications were received from industry. Later in the year personnel at the University of Western Ontario were invited to apply for an additional grant for research on a project (cutworm control) which the Advisory Committee considered urgent. Total funds requested for research (27 proposals) during 1976-77 amounted to $376,806. (A list of research proposals submitted to the Advisory Committee for consideration in 1976-77 is available on request).

Applications were considered first by the Research Subcommittee (Drs. C. D. Fowle, R. Frank, D. N. Huntley, F. L. McEwen, A. J. McGinnis, G. R. Stephenson, and C. R. Harris (Chairman)), and then by the Advisory Committee. Nineteen proposals were accepted (Appendix II), valued at $148,172. The average value was $7,798 ($3,000-$19,360). All grants went to universities (Guelph - 9, York - 4, Western Ontario - 3, Toronto, Brock, Waterloo - 1 each).

Direction and progress of the research program were monitored by the Advisory Committee in several ways. Initially several applicants were asked to modify their proposals to better meet the Committee objectives. In two instances the Committee invited proposals on specific problems. Informal contacts between the research subcommittee and some of those holding grants were established or maintained during the year. Recipients of grants were asked to provide a progress report (Abstract) by December 31, 1976. These are included in this report (Appendix III). In January 1977, the Advisory Committee sponsored a two-day meeting at which recipients of grants presented reports of their progress. This meeting, held each year for the past three years, has been most successful. It enables members of the Advisory Committee to meet the scientists involved, assess their work, and make constructive suggestions. The scientists are equally enthusiastic, as the meeting provides them with an opportunity to present results of their research, and to meet with others involved in pesticide research. Attendance at the meeting is not restricted to recipients of grants and Advisory Committee members. Invitations to attend are sent to university, government, and industry personnel known to be interested in pesticide research. Over 100 individuals attended the meeting in 1977. Published research reports relating to work supported by the Advisory Committee, theses, etc., are listed in Appendix IV.

Progress made in 1976-77 relative to the objectives of the program may be summarized as follows:

Objective 1: To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

Two grants ($9,000) related to this objective.

As has been pointed out in other Advisory Committee reports (OPAC, 1974a, b, 1975a, 1976) alternative less persistent insecticides were available for control of most insect pests in Ontario when use of the organochlorine (OC) insecticides was restricted in 1969-70. Alternative control measures were lacking for some soil insect pests (OPAC, 1974a) and for biting flies (OPAC, 1975b). Research, stimulated by grants from the Advisory Committee resulted in registration of one insecticide (leptophos) which was effective against cutworms attacking vegetable crops (OPAC, 1974b). In addition, a study on the biology and control of the crucifer flea beetle was completed (OPAC, 1975a, 1976). The Advisory Committee also funded a comprehensive study on the biting fly problem in Ontario (OPAC, 1975b), which has served the Ministry as a guide in initiating and funding a biting fly research program; and organizing an effective mosquito abatement program in relation to Encephalitis control.

The organophosphorus (OP) insecticide, leptophos, developed for control of cutworms attacking agricultural crops in Ontario, has been subject, for several years, to attack on the basis that it constituted a

health hazard. Although most of the leptophos used in Canada was applied by growers in Ontario and no reports of accidental poisonings were received, the Federal Government banned its use in 1977. Cutworms are a serious pest of agricultural crops in Ontario. While there are three possible alternative insecticides which could be used (chlorpyrifos, DDT, chlordane) the first can be phytotoxic to some crops, which the other two are persistent OC insecticides. The Advisory Committee recognized an urgent requirement to encourage research to develop effective alternative insecticides. One grant (19) * was awarded early in 1977 to initiate this research.

One OC insecticide, chlordane, is still used for control of insects attacking turf. Effective alternative control measures using less persistent chemicals or non-chemical methods of control will be achieved only through development of a thorough knowledge of the species and life histories of turf insect pests. One grant was awarded to encourage research in this field (16). Information on the occurrence and life history of two species of turf insect pests was obtained.

Objective 2. To determine potential environmental hazards with pesticides presently in use.

Eight grants totalling $64,248 were allocated to this objective.

There is ample evidence that residues of the persistent OC insecticides accumulated to significant levels in agricultural soils in Ontario through the 1950's and 1960's. Following restrictions on their use, residues of these insecticides are now declining. OP and carbamate (C) insecticides were assumed to be less persistent and research data indicate that these compounds are not accumulating in mineral soils to any significant extent. However preliminary data presented to the Advisory Committee several years ago indicated that some OP insecticides were accumulating in organic soils used for vegetable production. A project (17) funded, in part, by the Advisory Committee, and completed in 1976 has shown that: 1) OP insecticides are markedly more persistent in organic as compared to mineral soils; 2) residues of OP insecticides are present at significant levels in Holland Marsh soils, and are two to three times as high as cyclodiene insecticide residues; 3) the major OP insecticide residue in organic soils is ethion which is used solely for onion maggot control; 4) OP insecticide residues are present in all major organic soil areas used for vegetable production in Ontario, although at lower levels than in the Holland Marsh; 5) OP insecticides are present at ca. 70% of the level of OC insecticides in the Schomberg River system draining the Holland Marsh, with the predominant OP insecticide being diazinon; and 6) OP insecticide residues could be detected (qualitatively) in air samples collected at the Holland Marsh throughout the growing season.

---

* Numbers in brackets refer to Abstracts of projects in Appendix III.

Some herbicides are also used for weed control on organic soils. As a result of the finding that OP insecticides were accumulating in these soils, a study (14) was initiated in 1975 and continued in 1976 to determine the extent to which linuron and chlorbromuron were persisting in organic soils. Preliminary results indicate that both materials are relatively persistent.

Fungicides are also used extensively in Ontario. Environmental studies have been hampered by lack of sufficiently sensitive analytical procedures. Continued emphasis was placed on development of a reliable, sensitive analytical procedure for the systemic fungicide, benomyl, which is receiving wide use in Ontario (3). Development of a satisfactory method of analysis was completed and studies were initiated on the fate of benomyl in crops.

The extensive use of OP insecticides on vegetable crops grown on organic soils and the residues detected in soil,water, and air raised a question as to whether the health of humans working or living in the Holland Marsh environment would be affected. Exposure to OP insecticides produces acetylcholinesterase inhibition in human plasma. While not entirely satisfactory as a measure of OP insecticide poisoning determination of blood cholinesterase levels can be used as one indicator. At the suggestion of the Advisory Committee, a study (2) was conducted to establish blood cholinesterase levels in different groups of people living and/or working in the Holland Marsh during different times of the year. The results indicated that some growers/ workers /packers were suffering from overexposure to OP insecticides during the growing season. The effects were transitory and cholinesterase activity returned to normal when exposure ceased. The results of this study are being published (Brown et al, 1977) and will be used when counselling farmers and workers on the proper use of, and hazards associated with OP insecticides.

OC insecticides have the potential to cause drastic effects on non-target, particularly aquatic, organisms. Residues of some OP insecticides, particularly diazinon, are being detected, usually at very low levels in agricultural watersheds. Moreover some OP insecticides are applied directly to water for mosquito abatement. Thus for several years considerable emphasis has been placed on determining potential effects of OP insecticide residues on non-target aquatic organisms. Several studies were completed in 1976. Three studies (1, 4, 6) on the persistence of three mosquito larvicides (chlorpyrifos, methyl chlorpyrifos, and temephos)in water and the responses of bacteria, algae and invertebrates to application of these larvicides were completed. In artificial ponds chlorpyrifos was more persistent in water and litter > temephos > methyl chlorpyrifos. Persistence appeared to be related to formulation. The insecticides persisted longer in artificial than natural ponds. In artificial ponds chlorpyrifos and temephos reduced zooplankton and stimulated algal development. (OPAC 1976). More intensive studies, under laboratory conditions, indicated

that growth responses of different algal groups to low concentrations of chlorpyrifos and temephos were variable. In some cases algal growth was stimulated while in others it was inhibited. At relatively high concentrations chlorpyrifos stimulated nitrogen fixation in one species of blue-green algae whereas temephos did not. Assessments carried out in conjunction with operational mosquito abatement programs in 1976 indicated that temephos initially suppressed populations of non-target zooplankton but that they soon recovered. None of the areas available for monitoring was sufficiently stable or persistent to allow study of possible increase in algae after the pesticide applications. The effect of diazinon on stream invertebrates has also been assessed for several years (11). Results of this investigation indicated that in the laboratory, diazinon was toxic to several species of stream invertebrates but usually at concentrations in excess of those detected under practical conditions. Sublethal concentrations had some minor effects on behaviour of some species of stream invertebrates. Under practical conditions repeated applications of 3 ppb diazinon to a stream caused temporary changes in stream invertebrate populations. Recovery occurred within four weeks after treatment of the stream with diazinon was halted.

Objective 3. To reduce total pesticide input into the environment.

The only practical solution to any environmental problem is to reduce input of the contaminant into the environment. One approach is to simply forbid the use of a contaminant. The pesticide problem is more complex. Control of pests attacking agricultural crops, forests, or man and his animals is essential. Current pest control programs are reliant on the use of chemicals. If one chemical is banned another must usually be substituted in its place. The new chemical may also have potential to pollute, perhaps in a manner with which we are not currently familiar or have the technology to assess. On the other hand, there are promising possibilities of reducing pesticide input into the environment by modifying current pest control programs in a manner that less chemical will be required while still achieving as or more effective pest control. The Advisory Committee considers this to be the major goal of our research program and supported nine research projects valued at $74,924, in 1976-77.

Pesticides are often applied as "insurance" treatments; i.e. the grower is not sure that the pest will be present, but cannot afford the risk that it will occur. Often treatment is not required since the pest will be present at a low level and would not cause serious damage. It is thus important to determine economic thresholds of damage below which pesticide applications would not be required. During 1976-77 a study was continued on the economic threshold of cereal leaf beetle on oats and barley in Ontario (5). Results indicated that: 1) the spread of the cereal leaf beetle is continuing,

reaching levels of economic importance in some areas; 2) a parasite of the cereal leaf beetle is well established providing a degree of biological control; 3) because of the potential for biological control there is good reason to develop economic thresholds for cereal leaf beetle in order to minimize chemical applications which could be detrimental to the parasite; 4) the current economic thresholds for cereal leaf beetle can be revised upward.

Development of more effective pest monitoring techniques would also result in a marked reduction in pesticide input into the environment, i.e. with applications properly timed to the appearance of the pest, there would be less requirement for "insurance" applications. The Advisory Committee supported four studies related to development of pest monitoring techniques in 1976-77. The apple maggot is of major economic importance in Ontario. The current pest monitoring technique is not satisfactory. Two related studies on development of a synthetic sex attractant were supported. Several candidate compounds were synthesized for assessment as sex attractants (13) but did not prove effective in their field (12). In addition work was begun on development of a laboratory procedure for assessing effectiveness of candidate compounds as pheromones. Data were also collected to determine the threshold of development and degree/days required for emergence of adults. The latter information should assist in predicting when control programs should be initiated (12). A technique of monitoring for the emergence of onion maggot adults is also being developed (15). The degree/day technique, flight interception cages, and traps, show promise in predicting appearance of first, second and third generation adults with considerable accuracy. Using these monitoring techniques a field test in 1976 indicated that sprays applied for adult control could be reduced markedly. The Advisory Committee has supported a similar approach toward reducing fungicide use on vegetable crops by scheduling sprays according to weather data for several years (8). Earlier OPAC research reports indicated that this approach appeared feasible in field trials for control of carrot leaf blight. In 1976 tests were conducted in commercial fields of carrots. A reduced number of fungicide sprays applied on a timed basis provided control as effective as a regular spray program. Field trials also indicated that it may be feasible to control onion blight in a similar fashion.

Pesticide application techniques are crude and often only a fraction of the pesticide applied actually reaches the target. Development of better application techniques would result in better pest control with less environmental contamination. Two programs were supported. A study has been funded for several years to assess the feasibility of designing an electrostatic sprayer (10). In 1976 a sprayer was designed to work in conjunction with commercial application equipment and was tested in the laboratory and field. The field tests, done late in the season, were spoiled because of poor weather conditions. In another study aimed at reducing herbicidal drift in roadside spraying

addition of an adjuvant to the spray mixture resulted in a significant reduction in spray drift both on roadside and field crop spraying (18). In another series of tests on roadside spraying, two of three adjuvants tested virtually eliminated drift while the third reduced it significantly.

Alternative non-chemical methods of pest control may be practical in some instances. Three investigations to this end were supported in 1976. Research on the feasibility of utilizing the sterile male technique for control of the onion maggot was continued (15). Promising results were obtained with an integrated control program using a soil insecticide for control of first generation onion maggot, followed by release of chemosterilized adults for second and third generation control. The integrated program required fewer insecticide applications, but maggot control was as or more effective than that obtained with the chemical programs and the number of overwintering pupae was much smaller. In another study, a survey indicated that disease control on turfgrass in Ontario is dependent almost entirely on fungicides (7). Benomyl was the most widely used. The principal turfgrass diseases were identified and laboratory and field studies on their control were begun. The survey referred to above also indicated that there is little information available on alternative approaches to disease control on turfgrass. Some preliminary work on development of management techniques for control of turfgrass diseases was started. Another study to determine whether some agricultural soils or practices were suppressive to bean root rot in Ontario was funded (9). A survey indicated that the intensity of root rot varies from one farm to another. There was an indication that this was related to either management practices or fertilization.

ASSESSMENT

In assessing the research program over the past few years, it is apparent that remarkable progress has been made, even though the research fund is limited and the average value of grants awarded is relatively small. The Ministry of the Environment deserves credit for its foresight in allowing the Pesticides Advisory Committee considerable latitude in the manner in which it operates the fund. Because of this the Advisory Committee has been able to locate, support, and cooperate with scientists who are genuinely interested in pesticide research. At the same time the Advisory Committee has been able to avoid the extreme amount of paperwork and red tape which is characteristic of many granting agencies. Applications for financial support are processed quickly by highly qualified people and the simplified method of reporting is very satisfactory to both the Advisory Committee and recipients of grants. The value of the research done far exceeds the investment made by the Ministry. In part, this is due to the fact that a small grant given at a strategic location, or time, often stimulates initiation or continuation of a comprehensive research program by another government agency (Ontario Ministry of Agriculture and Food or Agriculture Canada) or a university.

As pointed out earlier (OPAC,1976) most of the immediate problems falling under Objective 1, have been accomplished. Alternative control programs have been developed for most agricultural pests for which no control measures were available when use of the OC insecticides was restricted in 1969-70. Effective mosquito abatement programs are now in place in Ontario, and the Ministries of Environment and Health are sponsoring research on the biology and control of biting flies. Some problems remain. With the banning of leptophos by the Federal Government, priority must be given to developing other insecticides for cutworm control. Turf insects and some other soil insects are still controlled to a considerable extent with chlordane, one of the few uses remaining for OC insecticides. Development of effective less persistent chemicals or non-chemical approaches to control of these pests is desirable. New problems can be expected to arise. Earlier reports (OPAC, 1975a, 1976) indicated that recent crucifer flea beetle outbreaks in Ontario could be related, in part, to the fact that residues of DDT and dieldrin in agricultural soils are declining below biologically active levels. Until now these residues had provided "accidental" control of flea beetle larvae. Similar problems may eventually develop with other soil insect pests, e.g. wireworms, white grub.

Under our second objective, good progress has been made in defining the persistence and fate of pesticides in the environment. Residues of pesticides presently recommended for use against pests of crops grown on mineral soils do not appear to constitute a problem. However, results reported have already indicated that residues of OP insecticides are accumulating in organic soils used for vegetable production in Ontario, and in the case of the Holland Marsh, in the air and watershed. The extensive use of these insecticides is resulting in development of insect, e.g. onion maggot, resistance and could also constitute a hazard to the health of growers and packers if proper precautions are not taken. The occurrence of these residues in organic soils relates primarily to control programs used for two insect pests -- the onion maggot and carrot rust fly -- and it is clear that priority should be given to developing better control programs for them. Preliminary studies indicate that residues of several OP insecticides and herbicides persist much longer in organic as compared to mineral soils. Under this objective research has also been supported for several years to define potential hazards of pesticides to non-target organisms. The results indicate that, with some exceptions, the effects of residues of most pesticides currently recommended in Ontario on non-target soil and aquatic organisms will be minimal.

As noted above, the Advisory Committee feels that priority should be assigned to the third goal of reducing pesticide input into the environment while still achieving as or more effective pest control. In the short term perhaps the most promising approach is to develop effective pest monitoring techniques, thus replacing "insurance" sprays with ones which can be carefully timed. Progress on development of

pest monitoring techniques is encouraging. Both short and long-term benefits can be derived through the development of better application techniques. Drift from spray applications has always been a problem and it is encouraging to note that some adjuvants will reduce drift significantly. In the longer term development of application equipment which would deposit a higher percentage of the pesticide on the target site would reduce environmental contamination. Development of economic thresholds of pest damage and alternative approaches to pest control represent the ultimate long-term solution. However, it is important to realize that these approaches will be feasible in only a limited number of cases, and both development and implementation will be time consuming and expensive. The model programs currently being supported by the Advisory Committee will hopefully serve to illustrate to concerned federal and provincial agencies what could be accomplished if greater research support was provided for studies of this type.

The Pesticides Advisory Committee is very satisfied with research progress made in the past few years, and recommends continuation of the program. Part of the success of the program is due to the fact that it has been deliberately kept small allowing committee members (who all have other full-time responsibilities) to administer it with a minimum of effort. It is the feeling of the Advisory Committee that this approach should be maintained. Nevertheless, to maintain the same level of productivity, inflationary costs should be taken into consideration. The budget has not been increased for the past two years. We request that in 1978-79, the budget, currently $200,000/year, be increased to $225,000.

A further benefit, to which reference has not previously been made, is that several graduate students have been able to obtain excellent training relating to the impact and management of pesticides. This has resulted in a small increase in the number of people available to help in pest management programs; without such support they would have branched out into other areas and disciplines.

REFERENCES CITED

Ontario Pesticides Advisory Committee. 1974a. Review of soil insects in Ontario, 1900-1973. 28p.

Ontario Pesticides Advisory Committee. 1974b. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1973-1974. 33p.

Ontario Pesticides Advisory Committee. 1975a. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1974-1975. 36p.

Ontario Pesticides Advisory Committee. 1975b. In-house interim report on the mosquito problem in Ontario dealing specifically with encephalitis. 10p. (Confidential)

Ontario Pesticides Advisory Committee. 1976. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee. 42p.

Ontario Pesticides Advisory Committee. 1977a. Mosquitoes and mosquito control in Ontario. In press.

Ontario Pesticides Advisory Committee. 1977b. Human blood cholinesterase activity - Holland Marsh, 1976. In press.

APPENDIX I. Format of advertisement inviting applications for research grants from the Ontario Pesticides Advisory Committee, 1976-77

CALL FOR GRANT REQUESTS

The Ontario Ministry of the Environment has a limited amount of funds available for 1977 to sponsor research that will reduce overall use of pesticides and find alternatives, where possible, for those that may be environmentally hazardous. Funds will be made available on the basis of a negotiated contract for specific research projects. Preference will be given to proposals that will yield results in a relatively short time (less than three years), and the funds will be committed on a one-year basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest control including economic threshold levels of pests.

2. Studies leading to registration of environmentally acceptable pesticides especially for control of biting flies and pests of agricultural crops.

3. Reduction of pesticide use through development of effective pest monitoring techniques; alternative integrated or non-chemical methods of control; or improved application techniques.

4. Interactions and effects of pesticides or mixtures of pesticides on non-target organisms.

5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas, and on exposure of agricultural workers to pesticides.

6. Studies on the persistence, fate and biological significance of pesticides in the environment with particular reference to pesticides widely used in Ontario.

7. Study on economics and control of mammalian and avian pests.

APPLICATION PROCEDURE

Research proposals should be submitted to:

The Chairman, Pesticides Advisory Committee
Ontario Ministry of the Environment
Fifth Floor, Mowat Block, Queen's Park
TORONTO, Ontario. M7A 1A2.

Applications should include the following:

1. Title of project.

2. Name, address and affiliation of applicant(s).

3. Discussion of problem. (Applicants applying for continuation of a grant should include a progress report).

4. Clear statement of objectives.

5. Plan for the program.

6. Facilities available to the researcher for the conduct of the program.

7. Budget-categorize costs as: Personnel - full time and part time; equipment; supplies; overhead costs; other.

8. Listing of current projects and other sources of funding.

9. Curriculum vitae on principal investigator(s).

Applications should be received by February 27th, 1976.

APPENDIX II. Research projects supported by the Ontario Pesticides Advisory Committee, 1976-77

No.	Applicant	Location	Project Title	Amount Granted
1.	Boyer, M. G. Fowle, C. D.	York University	The response of bacteria, algae and invertebrates in small ponds to applications of mosquito larvicides	$ 8,700
2.	Brown, J. R. Stopps, G. J.	University of Toronto	Blood cholinesterase levels of field workers and packers of Holland Marsh	11,300
3.	Chiba, M.	Brock University	Simultaneous determination of intact benomyl and its degradation product (MBC) in plants in relation to their biological activities	4,200
4.	Colman, B.	York University	The effect of mosquito larvicides on algal productivity and the uptake of inorganic substrates by phytoplankton	3,442
5.	Ellis, C. R.	University of Guelph	The economic threshold of the cereal leaf beetle, Oulema melanopus (L) on oats and barley in southwestern Ontario	8,000
6.	Fowle, C. D. Boyer, M. G.	York University	Comparison of the responses of bacteria, algae and invertebrates to experimental and operational applications of mosquito larvicides	7,886
7.	Fushtey, S. G.	University of Guelph	Disease control in turfgrass - an integrated approach to control of Helminthosporium blights and Sclerotinia dollar spot	4,640
8.	Gillespie, T. J. Sutton, J. C.	University of Guelph	Reduction of fungicide usage on vegetable crops by timing fungicide applications according to weather data	11,044

APPENDIX II (Continued)

No.	Applicant	Location	Project Title	Amount Granted
9.	Hall, R.	University of Guelph	Natural control of soil-borne plant pathogenic fungi	$ 7,000
10.	Inculet, I. I. Castle, G. S. P. Kelly, C. B.	University of Western Ontario	Electrostatic application of pesticides in orchards and field crops	5,500
11.	Kaushik, N. K.	University of Guelph	Effects of sublethal concentrations of diazinon on stream invertebrates	6,360
12.	Laing, J. E.	University of Guelph	Development of a synthetic sex attractant for monitoring apple maggot	8,000
13.	Leznoff, C. C.	York University	The chemical synthesis of candidate sex attractants for the apple maggot	8,000
14.	Mayfield, C. I.	University of Waterloo	Linuron and Chlorbromuron residues in organic soils used for vegetable production in southwestern Ontario	3,000
15.	McEwen, F. L.	University of Guelph	Development of an effective monitoring technique and an alternative non-chemical method of control for the onion maggot	17,740
16.	Sears, M. K.	University of Guelph	Population studies and damage assessment of an aphodiine dung beetle, Ataenius spretulus Harold (Coleoptera: Scarabaeidae) on turf grasses	5,000
17.	Spencer, E. Y. Miles, J. R. W. Chapman, R. A.	University of Western Ontario	Persistence and mobility of residues of organophosphorus insecticides used for vegetable production on organic soils in southwestern Ontario.	19,360
18.	Stephenson, G. R.	University of Guelph	Methods to reduce herbicidal drift in roadside spraying	5,000

APPENDIX II (Continued)

No.	Applicant	Location	Project Title	Amount Granted
19.	Svec, H. J. Chapman, R. A. Harris, C. R.	University of Western Ontario	Control of cutworms attacking agricultural crops in southwestern Ontario	$ 4,000
	Total			$148,172

APPENDIX III. Progress reports (Abstracts) on projects funded by the Ontario Pesticides Advisory Committee, 1976-77.

---

1. Boyer, M. G.* and Fowle, C. D. - The response of bacteria, algae and invertebrates in small ponds to applications of mosquito larvicides.

A total of 10 ponds, two of them natural, the remainder polyethylene lined described previously (Butcher, Boyer, and Fowle, 1976) were treated with Dursban^{R}, Reldan^{R}, and Abate^{R} at 10 ppb to assess the relative stability of the insecticides under our experimental conditions.

The experiments were done in association with the Pesticide Laboratory of the Ontario Ministry of the Environment who performed the analyses.

A. Results

When the time taken for 80% of the pesticide to leave the aqueous phase was used as a measure of persistence, the end point varied depending on the pesticide and environmental factors. Dursban exhibited the greatest mean longevity in three experiments with a maximum of 122 hours. Reldan proved to be intermediate in persistence with a maximum of 31.2 hours followed by liquid Abate at 24.0 hours.

In experiments where comparisons were possible the variation in persistence among ponds could be interpreted on the basis of an inverse relationship between stability and temperature as shown by other workers (Schaefer and Dupras, 1970). When the loss with time from the aqueous phase was plotted on log-log paper, Dursban in polyethylene lined ponds, unlike any other experimental treatment, exhibited a straight line relationship rather than a curvilinear relationship, suggesting that Dursban in these ponds remains longer in the water.

Initially rates of adsorption on litter and polyethylene were very high declining gradually to zero as maximum levels of accumulation were attained. These peaks, the times of which varied with environmental conditions, were followed by more prolonged periods of desorption and/or decomposition. Rates of loss from polyethylene and litter were rapid for Reldan and Abate but much slower for Dursban. Litter and polyethylene did not differ significantly in their rates of adsorption. However the fact that the rates of accumulation of the pesticides by polyethylene equalled or slightly exceeded those of the litter suggest that more of the pesticides are adsorbed by the plastic than would be predicted on the basis of surface area alone.

B. Conclusions

1. Persistence in water of three pesticides, Dursban, Abate and Reldan, varied considerably with environmental factors. Dursban appeared to be the most persistent followed by Reldan and Abate

---

*_____: Recipient(s) to whom grant was awarded.

(liquid). Granular Abate in the single experiment reported was even more persistent than Dursban.

2. Abate, both granular and liquid, as well as Reldan are undetectable in litter, polyethylene and water after a maximum period of approximately thirty days under the conditions of these experiments.

3. Dursban on the other hand disappears much more slowly from the litter and ethylene although not necessarily from the water. Approximately 40 to 50% of the maximum adsorbed was still present on litter and polythylene after 21 days. At this time concentrations had fallen to near the limits of detectability in the natural pond while still clearly detectable in the polyethylene-lined ponds.

4. Litter in the simulated ponds accumulated far higher concentrations of the pesticide than litter in the natural pond. This, in addition to the quantities accumulated by the polyethylene, probably account for its apparent greater persistence in the water of artificial ponds.

2. Brown, J. R. and Stopps, G. J. - Blood cholinesterase levels of field workers and packers of the Holland Marsh.

Exposure to organophosphorus pesticides produces acetylcholinesterase inhibition in human plasma. The present study examines the extent of cholinesterase inhibition in a select population, living and working in an area where the application of organophosphorus pesticides is significant. The area is the Holland Marsh, which is located 30 miles north of Toronto, Ontario, occupying an area of 7,500 acres with predominantly muck soil.

Seasonal variations in cholinesterase levels among different sections of the population have been determined. The populations considered were farmers involved in spraying activity throughout the season, persons living within the designated area but not involved in spraying, produce packers, children, residents in the marsh and a control group having no specific involvement with the activity of the area, as well as a group of students from the University of Toronto with no involvement, either practically or environmentally with organophosphorus pesticides. The rate of application of organophosphorus pesticides is of the order of 11 tons per year over the whole marsh area.

It was found that early tests carried out on farmers at the beginning of the growing season yielded significantly higher cholinesterase levels than samples taken from the same individuals examined during the height of the growing season. Results obtained from school children were significantly higher than those from farmers or produce packers and were similar to those obtained from the non-exposed control group. The University student population gave a similar result to that obtained from the initial

control group. In some cases low values of cholinesterase activity were found among farmers. This was apparently due to exposure in greenhouses as a result of inadequate protective clothing. Persons having low levels of cholinesterase activity were re-examined and counselled as to the proper usage of the pesticides involved.

From analysis of the results obtained it would appear that some farm workers are suffering from over-exposure to organophosphorus pesticides. However, these results are transitory and a rapid return of cholinesterase activity to the normal level usually occurs.

There is no doubt that a danger exists, but it is not so serious as might seem to be indicated by the heavy use of organophosphorus pesticides over a relatively small area. It is recommended that a regular check program should be maintained in order to obviate a potential hazard.

3. Chiba, M. - Simultaneous determination of intact benomyl and its degradation product (MBC) in plants in relation to their biological activities.

Further development of the method: The method reported last year has been extended so that a non-automatic scanning type of spectrophotometer can be used as follows: Absorption of the sample is measured at 294 mu before and after adding butyl isocyanate (BIC). From a standard curve prepared, both intact and total benomyl concentrations are determined.

Effect of temperature: Degradation of benomyl (dissolved in either benzene or chloroform) to MBC and BIC was shown to be more rapid at high than at low temperatures. It is essential, therefore, that a constant low temperature be maintained during extraction of the residue if the true concentrations of benomyl and MBC are to be determined.

Formulation analysis: Two kinds of commercial formulations of benomyl were analyzed after a simple chloroform extraction. Results supported the values indicated by manufacturers. Benlate 50% WP contained 48.3% intact benomyl and 5.3% MBC. A mixed WP formulation of benomyl and Captan (benomyl 10%) contained 8.7% intact benomyl and 1.8% MBC.

Fate of benomyl after application: Intact benomyl residues from treated field grown cabbage showed little difference in samples collected immediately after application and those collected after 7 days. Moreover, the sample kept frozen for one year showed essentially no degradation: 91% of residue still remained as benomyl. In contrast there was a slow, but consistent degradation of benomyl with time on treated apple and peach leaves. Two weeks after application, 66% and 55% of residues were found to be intact benomyl on apple and peach leaves respectively.

4. Birmingham, B. C., and Colman B. - Impact of Abate and Dursban on algal productivity and the uptake of inorganic substrates by phytoplankton.

Seven freshwater algae were grown in the presence of Abate^{R} and Dursban^{R} at 1, 10, and 100 ppb active ingredient. The response of different algal groups to the insecticides was highly variable.

The growth rate of the nitrogen fixing blue-green alga Anabaena flosaquae was increased from 22% at 10 ppb Abate to 58% at 100 ppb Abate. Dursban caused similar growth stimulation. The green alga, Chlamydomonas reinhardii, showed growth stimulation in response to ppb Dursban.

Significant decreases in growth rate were observed for the green alga, Chlorella pyrenoidosa following treatment with 10 ppb Abate (8%) and 100 ppb Dursban (12%). The diatom, Navicula pelliculosa gave decreases in growth rate of the same order with 10 ppb Abate or Dursban.

No significant effect on the growth rates of the diatom. Navicula minima the blue-green alga, Coccochloris peniocystis or the filamentous green alga, Mongeotia was detected following treatment with either insecticide.

In a preliminary series of experiments, seven to eight day old cultures of Anabaena flosaquae were exposed to 1, 10 and 100 ppb Abate or Dursban and nitrogen fixing activity assayed after 4 and 24 hours. After 4 hours, the rate of nitrogen fixation was significantly higher in cells exposed to 100 ppb Dursban and this effect was maintained after 24 hours. No significant effect on nitrogen fixation rate was observed after treatment with Abate.

5. Ellis, C. R. - The economic threshold of the cereal leaf beetle, Oulema melanopus (L) on oats and barley in southwestern Ontario.

The cereal leaf beetle (CLB) was first found in southwestern Ontario in 1965. Since that time it has dispersed across most of southwestern Ontario causing damage in some fields of spring grain. In 1974, oat fields as far north-east as Wellington county were sprayed for cereal leaf beetle and in 1976 economic damage occurred on Manitoulin Island for the first time.

In 1976 populations of the parasite, Tetrastichus julis were again monitored, especially on Manitoulin Island. The percentage of parasitized CLB larvae remained high. The parasite was present on Manitoulin Island and the percent parasitism in July was approximately 80%.

In 1976, the caging experiments on oats and barley at various stages of plant growth were continued as in 1975 except that the experimental plots were located on the research farm at Guelph. Oats and barley were planted at 2 week intervals to insure grain at various stages of growth when larvae were abundant. Four levels of CLB larvae were caged on barley at the 4-5 leaf stage and on oats at the shot-leaf stage and head stage of growth. Each treatment was replicated three times and results were subjected to an analysis of variance. Results are still preliminary but the 1975 and 1976 data agree. Oats in the head stage tolerated 8 larvae/plant without yield loss and oats were more tolerant than barley. Barley at the 4-5 leaf stage infested with 3 larvae/plant produced significantly higher yields than the checks.

In 1976, the small plot experiments were supplemented by field experiments on Manitoulin Island where large numbers of larvae were present.

The test field at Manitoulin was mixed oats and barley. Sampling on June 23 and 29 determined that greater than 10 larvae/plant developed on oats, and between 2 and 3 larvae/plant on barley. The grain was at the shot-leaf stage, at this time, and part of a field was sprayed with carbaryl as recommended for control of cereal leaf beetle. The yield was determined from 5 samples of 30 randomly selected plants. Yields were not significantly different although 1% lower. Even if these 1% reductions were real, the return in chemical control would not pay for the insecticide and labour. The data on both oats and barley was analyzed with respect to the total number of tillers and the number of tillers with seeds. These were not significantly different for either oats or barley.

Although one more year of data is needed before firm conclusions can be made, some tentative conclusions can be drawn: 1) the parasite T. julis is well established in Ontario, even on Manitoulin Island where the pest has recently spread; 2) there is good reason to develop economic thresholds for CLB so as to minimize sprays that will hinder biocontrol; 3) the economic thresholds in Ontario can be revised upward.

6. Fowle, C. D., and Boyer M. G. - Non-target invertebrates and the use of Abate for the control of mosquitoes and encephalitis in urban areas.

The primary objective of this study was to compare our observations on the effect of Abate on non-target organisms under experimental conditions with the impact of the compound in an operational program to control mosquitoes responsible for the transmission of encephalitis. As the program developed opportunities arose to compare the expectations of the public and those responsible for control before the program started with what really happened. We also gained experience in assessing the impact of the pesticide in a practical setting.

We could not have undertaken the work without the generous cooperation of the responsible officials of the Boroughs of North York and Scarborough and the Peel Regional Health Unit.

We began by establishing a liaison with those carrying out the control program which kept us informed on the day to day mapping of potential mosquito breeding sites and plans for applying Abate. We were able to monitor several applications in different settings and to draw up a rough classification of wetland types covered by the program.

Our main results can be summarized:

1. The scope of the control program in the three municipalities was much less than originally anticipated. A relatively small area of wetland was treated.

2. Abate suppressed populations of non-target zooplankton such as cladocera and cyclopods but they soon recovered. Rotifers,

some insects and snails seemed not to be affected. The temporary loss of some populations of non-target species is not in our opinion a cause for concern.

3. None of the areas available for monitoring were sufficiently stable or persistent to allow us to study the possible increase in algae after pesticide application.

4. The types of water areas treated were generally very small, temporary, and so located as to make contamination of streams or major water areas very unlikely.

5. Monitoring natural wetlands and water areas subject to treatment was very difficult owing to the variation in biotic communities, fluctuations in water levels, the ephemeral nature of many of them, and the non-random distribution of organisms in them.

7. Fushtey, S. G. - Disease control in turfgrass - an integrated approach to control of Helminthosporium blights and Sclerotinia dollar spot.

A total of 39 gold courses, largely in the Guelph-Hamilton-Toronto area, were visited, superintendents interviewed and details of management, especially as relating to disease control recorded. The records showed that 14 different kinds of fungicides were being used for disease control. Benomyl was by far the most widely used single fungicide and in nearly half the instances was the only one used. Management other than the use of fungicides was not knowingly employed for disease control.

The principal diseases requiring control were Helminthosporium Blight, Dollar Spot and Snow Mold. Another disease that was serious in a few locations, could not be readily diagnosed and did not respond well to control with fungicides, was found to be associated with an abundance of the fungus Curvularia. A project has been initiated to study the biology and importance of this fungus in turfgrass pathology. Special attention was given to recording instances where the Dollar Spot fungus, Sclerotinia homeocarpa, showed resistance to Benomyl, a situation which was noted in the 1975 survey. Eight such instances were encountered in 1976. In each case the fungus was isolated into pure culture and studied in the laboratory. These isolates showed varying degrees of tolerance to Benomyl but two of them tolerated as much as 1000 ppm, whereas the normal form of the fungus is completely inhibited at 1 ppm.

In a field trial at the Cambridge Research Station where one of the Benomyl-resistant forms of Sclerotinia isolated in 1975 was used to incite disease, all formulations of Benomyl and related compounds tended to increase rather than decrease disease. Only the broad-spectrum fungicides containing mercury, anilazine, chlorothalonil or glycophene gave satisfactory control. In a field trial with Helminthosporium Blight, most of the fungicides used reduced disease. Disease was less severe

when the turf was maintained at a 4 cm as compared to a 2 cm mowing height. Observations on an experimental set-up to compare the combined effects of mowing height and fertility were inconclusive. Such effects are not likely to be fully expressed in one season. The treatments and observations will be continued in 1977.

The results of this study have shown the need for research in several areas of turfgrass pathology. Probably the most striking revelation is the total dependence on fungicides for disease control. This, however, is not surprising. There is so little information available on alternatives.

8. Gillespie, T. J. and Sutton, J. C. - Reduction of fungicide usage on vegetable crops by timing fungicide applications according to weather data.

Many growers in the Holland Marsh attempt to control carrot leaf and onion leaf blight with protective spray programs wherein fungicide is applied regularly, usually every 5 to 10 days. Application is wasteful, consumes energy unnecessarily, and adds to the pesticide load in the environment. Our objective is to reduce fungicide use by developing a monitoring program related to timing fungicide sprays on carrots and onions according to weather conditions.

Earlier field trials with carrots indicated that this approach is feasible. In 1976, with the aid of grower cooperators, the scheme was tried on a commerical scale. Four growers agreed to spray an area of an acre or more of their carrot fields using timed sprays related to weather conditions, while four other growers proceeded with regular spray programs. The "timed" fields were protected with 2 to 4 sprays, while 6 to 7 sprays were applied to the regular fields. The reduced number of sprays applied on a timed basis related to weather conditions was as effective as the regular spray program in controlling carrot blight.

The objective of the 1976 studies on onions was to specify the weather conditions conducive to the development of onion blight with the ultimate aim of developing a monitoring program for onions similar to that developed for carrots. A field trial was conducted at the Muck Research Station. In addition to untreated controls, other plots were subjected to either regular sprays applied at 10 day intervals (total of 7) or timed sprays (total of 4), based on incidence of blight and weather conditions. The reduced number of timed sprays was as effective as the regular spray program in controlling onion blight. It will be necessary to test the scheme on a commercial scale and further refinements in defining criteria for initiating the spray program may be necessary.

9. Hall, R. - Natural control of soil-borne plant-pathogenic fungi

Our objective was to determine whether soils or agricultural practices suppressive to bean root rot occur in Ontario. Symptons of this disease complex include stem necrosis, root necrosis, reduced root

and shoot growth and reduced seed yield. In field trials at 2 locations in Ontario in 1976 fumigation of soil with Vorlex doubled the size of root systems and doubled seed yield of dry beans, cv. Seafarer. We concluded that biological events in soil considerably restrict root growth and seed yield of dry beans. Thirty forms of fungi were recovered from bean root systems from 4 fields. Those likely to restrict root growth included Fusarium solani, Fusarium oxysporum, Pythium ultimum and Rhizoctonia solani. A survey of dry bean farms was initiated in 1976 and data collected on seed treatment, seeding date, crop rotation, fertilizer rates, form of nitrogen, herbicide use, bean cultivar, soil type and root rot rating. Soil samples were taken from 58 fields. To date, 12 have been tested in pots under growth room conditions for their propensity to cause root rot potential. Severe root rot in the field was associated with severe root rot or seed decay in pot tests. Low root rot in the field was associated with low to moderate root rot in pots. Pot tests with field soil therefore appear to be suitable for rapid screening of root rot potential of field soil. Two fields with very low root rot potential were identified. In one case, the farmer does not bother to treat bean seed with fungicide yet reports good crops. These soils will be tested to determine whether they prevent root rot developing when the pathogen is added and, if so, whether the suppressive effect can be transferred to other soils. The survey will be expanded in an attempt to locate agricultural practices which reduce root rot. To date, rates of nitrogen fertilizer applied to the bean crop appear most directly related to root rot in pot tests.

10. Inculet, I. I, Castle, G. S. P., and Kelly, C. B. - Electrostatic application of pesticides in orchards and field crops

The main achievement over the period has been the design construction and preliminary field testing of a full scale electrostatic sprayer. The sprayer has been designed to work in conjunction with a Kinkelder commercial unit. The unit was built by mounting on a two-wheel trailer: a water tank for containing the liquid pesticide (electrically insulated from the body of the trailer), a high voltage power supply, an air compressor, a 110-volt gasoline driven generator (to provide the necessary electrical power to the compressor and the high voltage power supply), control valves and insulated hoses to the ten nozzles of the modified Kinkelder blower.

The unit hitches on to the Kinkelder blower pulled by the tractor and it can be operated remotely from the tractor.

The modifications to the Kinkelder blower involve the replacement of the two metallic fan-shaped heads by cylindrical ducts (electrically insulated). Each cylindrical duct contains five nozzles which generate a concentrated spray aimed towards the centre of the tree foliage. The flow of the pesticide liquid can be regulated to spray up to half a gallon of liquid in four seconds/side. Due to various delays from the suppliers, the unit was completed late in the spraying season. After the initial electrical testing in the Applied Electrostatics Laboratory of the

University of Western Ontario, the unit was taken to the experimental orchard at Guelph for actual field tests. It was found to operate satisfactorily. However, certain modifications were required to the general arrangement of the nozzles as well as to the air flow pattern. We were able to carry out only two tests prior to the end of the spraying season. Poor weather conditions spoiled both tests; we had heavy rain during the first test and high winds during the second test.

The unit is now ready in our laboratory for a complete series of tests beginning early spring 1977. Arrangements have been made with Mr. John Gardner from the Department of Agriculture in London for possible testing in the London area. It is expected that by the end of the 1977 spraying season we shall have results on both the coverage obtained by electrostatic spraying and the effectiveness of the pesticide control.

11. Kaushik, N. K. and Morgan, H. G. - Effects of sublethal concentrations of diazinon on stream invertebrates

The acute toxicity of diazinon to 14 species of stream invertebrates was determined by static toxicity tests. The most sensitive of 4 species tested under short periods of exposure was the trichopteran Cheumatopsyche oxa Ross, with a 3-h LC50 of 0.19 mg/l diazinon and the most tolerant was the trichopteran Leptocella albida Walker (3-h LC50, 0.22 mg/l diazinon). Trichoptera species tested showed delayed mortality to diazinon. Under long exposure tests, the dipteran Chironomus tentans Fabricius was the most sensitive (threshold LC50, 0.27 mg/l diazinon) and the mollusc Helisome trivolvis trivolvis say, the most tolerant (168-h LC50, 0.528 mg/l diazinon).

Chironomus tentans was reared in sublethal concentrations of diazinon. A concentration of 0.003 mg/l diazinon equivalent to 0.11X the 168-h LC50, significantly delayed egg hatch, increased the duration of the larva stage, slightly depressed pupation and emergence of adults from puparia, and lengthened the time of development from egg to adult by 33.6%.

The effects of diazinon on the aggressive behaviour of the crayfish Orconectes propinquus Girard was examined in a flow-through system under continuous exposure to concentrations sublethal to O. propinquus. A concentration of 0.003 mg/l diazinon (0.2X the 168-h LC50) significantly increased locomotion of males and females, number and duration of fights between pairs of males and females, but male dominance over female was not affected.

Avoidance of diazinon by the crustacean Gammarus lacustris limnaeus Smith was tested by presenting the amphipod with a choice of moving into either clean water or water containing diazinon. The amphipod did not avoid lethal concentrations of diazinon as strong as 10X the 168-h LC50 for G. lacustris.

The effect of long-term continuous exposure to sublethal concentrations of diazinon on the activity of G. lacustris was tested in a flow-through system. Activity was measured as interruptions of a beam of ultraviolet light. A concentration of 0.003 mg/l diazinon, equivalent to 0.02X the 168-h LC50 for G. lacustris, caused a sustained increase of 1.7X in the level of activity.

Diazinon applied to a stream to obtain a desired concentration of 3 ppb for 20 min, increased the drift of chironomid larvae, Ephemerella spp., within the first 3 h of application. Repeated treatment of the stream with the same amount of diazinon for about 5 wk caused increased drift of chironomid larvae, Hydropsyche spp., and Cheumatropsyche spp. to persist for longer than 3 h.

Change in structure of communities of benthos in a stream receiving expected concentrations of 3 ppb diazinon for 20 min, at 3-day intervals for 11 wk, was assessed by providing artificial substrates for colonization and by the kick method. Sequential comparison and species diversity indices showed that diazinon caused a change in the structure of communities of benthos colonizing artificial substrates. Change in community structure was supported by comparison of dendograms derived from clustering the samples. The changes were temporary and the communities recovered within 4 wk after treatment of the stream with diazinon was stopped.

12. Laing, J. E. - Development of a synthetic sex attractant for monitoring apple maggot

During the peak flight period of the apple maggot, Rhagoletis pomonella, six chemicals were tested in Pherocon (R) insect traps for attractiveness to the adult flies. Controls consisted of the same traps baited with a protein hydrolosate, the standard attractant for apple maggot and other fruit flies. There was no significant attraction of adults to these chemicals.

Pupae which were collected during the late summer formed the basis for initiating a laboratory colony of this species. When diapause has been broken in the flies, the colony should produce sufficient numbers of adults to begin testing candidate chemicals by electro-antennograms and behavioural responses. The equipment for antennograms has been assembled and initial experiments are being conducted to obtain response curves as adults become available from the colony.

In conjunction with the foregoing experiments, data have been collected to determine the threshold for development of the over-wintering apple maggot pupae and the degree-days for emergence of the adult flies. These data should assist us in predicting when controls should be applied to reduce the numbers of this pest in Ontario.

13. Leznoff, C. C. - The chemical synthesis of candidate sex attractants for the apple maggot

Although the sex attractant of the apple maggot is unknown, the sex attractant of the common housefly, Musca domestica was shown to be cis-9-tricosene and the sex attractant from the male of the Mediterranean fruit fly Ceratitis capitata, was found to be a mixture of trans-6-nonen-1-ol and methyl trans-6-nonenoate (J. G. MacConnell and R. M. Silverstein. Angew. Chem. Int. Ed. 12 644 (1973).

These are the only two pheromones in the numerous Dipteran species that have been characterized. Fortunately the apple maggot occurs in the same sub-family as the Mediterranean fruit fly and hence it is highly likely that the unknown sex attractant of the apple maggot is similar in chemical structure to that isolated from the male of the Mediterranean fruit fly (M. Jacobson et. al. J. Med. Chem 16 248 (1973).

The candidate sex attractants that have been selected for chemical synthesis are based on the general structure shown below, where m=0-3, n=2-6, X=CH_2OH, CHO, CO_2ME and CH_2OAc, and the double bond is pure cis or pure trans.

$$CH_3(CH_2)_mCH{=}CH(CH_2)_nX$$

A 2% crosslinked insoluble polystyrene polystyrene polymer containing trityl chloride groups reacted with 1,5-pentanediol to give a monoblocked ether of a symmetrical diol. Mesylation of the free diol and coupling with 1-lithiobutyne gave a polymer-bound alkyne which on acid cleavage liberated 6-nonyn-1-ol.

From 6-nonyn-1-ol, six candidate sex sttractants were prepared according to the general formula and are listed below.

I	m = 1,	n = 4,	X = CH_2OH,	CH = CH = Trans
II	m = 1,	n = 4,	X = CHO	CH = CH = Trans
III	m = 1,	n = 4,	X = CO_2Me,	CH = CH = Trans
IV	m = 1,	n = 4,	X = CH_2OH,	CH = CH = cis
V	m = 1,	n = 4,	X = CHO,	CH = CH = cis
VI	m = 1,	n = 4,	X = CO_2Me,	CH = CH = cis

Suggestions for additional sex attractant candidates are made.

14. Mayfield, Colin I. - Linuron and Chlorbromuron residues in organic soils used for vegetable production in southwestern Ontario.

Experimental studies on the rate of decomposition of Linuron and Chlorbromuron in organic soils are being carried out. Field plots (1m x 1m) were used and the two herbicides applied at 1x the field application rate (1 X F.A.R.) and 5 X F.A.R. A total of 24 plots were used including 4 control plots not sprayed with herbicide. Ten-kg samples of the soil were also treated with the herbicides and incubated at 20°C and 4°C under controlled humidity conditions in the laboratory.

Gas chromatographic analysis of Linuron and Chlorbromuron levels in all soil samples was carried out at monthly intervals. The extraction efficiency using hexane was tested at intervals with 'spiked' soil samples. During the first 6 months of the study there were decreases in both Linuron and Chlorbromuron levels in the soils but the rate of decrease in these levels slowed during this period. Samples held in the laboratory showed similar results. Bioassay methods are currently being developed to determine whether any phytotoxic activity remained in the soil

15. McEwen, F. L., Caldwell, E., Harris, C. R., and Svec, H. J. - Development of an effective monitoring technique and an alternative non-chemical method of control for the onion maggot

During the past 2 years in a cooperative project between the University of Guelph and Agriculture Canada, laboratory and field studies have been carried out to determine if the degree/day technique can be utilized to monitor for the appearance of onion maggot adults in the Holland Marsh. Degree/day integrators designed by the Engineering Research Service, CDA, Ottawa were used. The approximate developmental threshold was established (45°F) and using it as a base, experiments were conducted at several other temperatures to determine the number of heat units necessary for one complete revolution of the life cycle (1017 heat units if diapause intervened, 985 if not). In 1975, integrators (measuring air temperature) were set up at the Keswick Marsh adjacent to flight interception traps. Adult populations were monitored daily through the summer. The results (Table 1) indicated that, while the native fly population appeared in the field slightly after the date predicted on the basis of the laboratory tests, the digital temperature indicator showed promise for predicting appearance of onion maggot adults, especially the second and third peaks.

Table 1. Degree/Day units required for development of the onion maggot in the laboratory and at Keswick Marsh, 1975. (Threshold temperature = 45°F).

	Laboratory		Field	Date of Appearance
	Mean	Range		
First appearance of flies	330	(308- 351)	394	24/5
First peak of flies	385	(357- 413)	477	30/5
Second peak of flies	1494	(1418-1570)	1521	16/7
Third peak of flies	2479	(2352-2606)	2537	28/8

In 1976 integrators based on °C. were used. Based on a threshold temperature of 10°C heat units required for development were again determined in the laboratory. Tests similar to those described above were again set up at the Keswick Marsh. As in 1975, each generation peak occurred slightly later than predicted on the basis of the laboratory tests (Table 2).

Table 2. Degree/Day units required for development of the onion maggot in the laboratory and at Keswick Marsh, 1976 (threshold temperature = 10°C).

Flies	Laboratory		Field	
	Mean	Range	Mean	Range
First appearance *	120	-	95	(86- 104)
First peak	149	(134- 164)	188	(142- 235)
Second peak	565	(558- 572)	587	(531- 563)
Third peak	981	(979- 982)	1084	(1015-1154)

* from diapause pupae

The results of the 1975-76 studies indicate that the degree/day technique using the digital temperature integrator shows promise for monitoring for the appearance of onion maggot adults. To date, fly appearance in the field has generally lagged slightly behind the predicted date of emergence. We suspect that this is primarily due to the fact that air temperatures (subject to much more fluctuation) have been monitored rather than soil temperatures. Also we have encountered technical problems with the integrators in terms of both accuracy and mechanical breakdown. Nonetheless over the past two years the integrators have proven very useful in predicting emergence peaks. This has aided greatly in determining timing of releases of sterile insects and of adulticide applications, where required. In 1976 adulticide applications on the "pesticide control" farm referred to below were limited to 6 whereas some growers used 2 to 3 X that number of sprays throughout the growing season.

Studies on the feasibility of using the sterile male technique as part of an integrated control program for onion maggot were continued. In 1975 promising results were obtained using a chemosterilant fed to adults prior to their release. This approach was tested on an 18 acre site at the Keswick Marsh in 1976. One million pupae were reared during the winter of 1975-76 and held in diapause. In the field an integrated control program was adopted. Ethion was used as a seed furrow treatment at 2 lbs AI/acre for 1st generation maggot control and 40,000 - 80,000 laboratory-reared chemosterilized adults/week were released throughout the period that onion maggot adults were present (3 generations). In

total 672,000 flies were released. An adjacent farm on a full insecticide program (ethion soil treatment for 1st generation maggot + 6 parathion sprays applied during the season for adult control) was also monitored. Results of the integrated control program (Table 3) as compared to the chemical control program were encouraging.

Table 3. Integrated control of the onion maggot on an 18 acre site at the Keswick Marsh, 1976.

	Control Program	
	Chemical	Integrated
Insecticide applications		
Soil	1*	1*
Adulticide	6**	2***
No. sterile flies released	0	672,000
Recapture ratio-sterile:native	-	2.4:1
Avg. % fertility of eggs	87 (58-97)	68(5-85)
Overwintering pupal population/sq.yd.	2.1	0.13
Maggot damage to crop	0.42%	0.02%

* Ethion, 2 lbs. AI/acre
** Diazinon or parathion at 0.5 and 0.3 lbs. AI/acre respectively
***Chlorpyrifos at 0.25 lbs. AI/acre

Insecticide input was reduced significantly in the integrated program. Both the integrated and chemical control programs gave excellent maggot control. Percent fertility of eggs was reduced significantly in the integrated program but not to the extent expected. However other studies, using marked adults showed that migration of adults occurs over an area of at least 1/4 mile. In view of the fact that numbers of live flies caught in traps for determination of % fertility of eggs are usually small, invasion of the experimental area by small numbers of fertile flies can have a marked effect on fertility data.

While the results of this work appear promising to date it is too early to predict whether either the degree/day monitoring technique or the program of integrated control will be practical. The former shows promise in bringing about a marked reduction in insecticide input in conventional spray programs provided mechanical problems with the digital integrators can be overcome. The sterile male technique has now given effective control of 2nd and 3rd generation onion maggot in a small experimental site for two years. However, in 1976 onion maggot populations were abnormally low. In addition more information is required on the biology of the onion maggot, particularly adult feeding habits and movement, since invasion of the experimental site over the past two years by fertile females from adjacent farms has confused the indices being used to assess the effectiveness of the technique.

16. Sears, M. K. - Population studies and damage assessment of an aphodiine dung beetle, Ataenius spretulus Harold (Coleoptera: Scarabaeidae) on turf grasses.

An informal survey of golf courses in the Toronto area, in 1976, revealed that only minor damage was caused by Ataenius spretulus and Hyperodes anthracinus. Adult flight activity of A. spretulus was monitored throughout the summer on one golf course and peak numbers occurred during the week of June 1st. Subsequent development of larval populations on surrounding fairways did not occur so that further evaluation on this course was terminated. On another course, slight damage to green aprons was observed in late July. A substantial density of A. spretulus was observed (135 ft^2) in the fairways, but virtually no damage was discerned in these infested areas. It appears that cool summer temperatures provided excellent growing conditions for fairway grasses and observable insect damage was minimized. An insecticide trial applied at this time was inconclusive due to the fact that a large percentage of the population was in the process of entering the pupal stage. Mortality due to milky disease was not detected in this population.

In 1975, some damage to trees and fairways on Toronto golf courses was attributed to the larvae of a weevil, Hyperodes anthracinus. It was decided to further investigate this problem in 1976. The life history of H. anthracinus is better understood than that of A. spretulus so that the investigation was primarily aimed at detection of the early activity of adult weevils, an assessment of their potential damage and strategies for control. An early emergence of adults from overwintering sites followed by a cold period led to a slow developing and poorly synchronized first generation. Although larval density decreased with increasing distance from overwintering areas on both a fairway site and a tee site, no differences in damage could be discerned. A second generation was observed, but damage by either the first or second generation was minimal, possibly due to excellent growing conditions.

17. Spencer, E. Y., Miles, J. R. W. and Chapman, R. A. - Persistence and mobility of residues of organophosphorus insecticides used for vegetable production on organic soils in southwestern Ontario.

Analyses of soil samples in the Holland Marsh during 1972-75 showed the continuing high concentration of organochlorine (OC) insecticide residues - especially DDT of which there was 60 ppm on one farm. At the 26.6 ppm marsh average for 1975, about 100,000 lbs of DDT still remain in the muck soil of the Holland Marsh alone. Ethion was the organophosphorus insecticide with the highest average concentration in soil - about 3.5 ppm in 1975 (6.9 in 1973). Soil samples from 28 farms in the Holland, Keswick, Colbar, Bradford, Thedford, Erieau, and Leamington marshes were collected in October. These soils represent the chief organic soil areas on which vegetables are grown in Ontario. The samples will be analyzed to compare the insecticide residue levels of the various muck areas. Laboratory and microplot field studies conducted at the Institute field station on the persistence of phorate and terbufos in sand and muck have shown that:

1)the results of lab and field studies closely parallel one another with regard to form (parent, sulfoxide, or sulfone) of the terminal residues; 2) the terminal residue of terbufos is dependent on soil type; 3) the total residues are much greater in muck than in sand representing 14 and 43% of the initial application of phorate and terbufos respectively in the field treated muck soil after 50 weeks; and 4) residues in the range of 0.1 to 0.3 ppm were observed in radishes and carrots grown in the sand during the first year after treatment but were in the range of 0.09 to <0.01 ppm for crops grown on muck. Only traces of residues were detected in crops grown during the second year. Chlorpyrifos was also more persistent in the muck as compared to the mineral soil. In other microplot studies sandy loam initially amended with calcium hydroxide and aluminum sulfate to pH 8.0 and 6.3 had changed to pH 7.8 and 6.9 respectively after 56 days indicating that this was an acceptable but not completely satisfactory method of altering soil pH in order to study the effect pH changes might have on selected insecticides in the field The rate of disappearance of fonofos and terbufos (and its sulfur oxidation products) from this soil was not affected by differences in pH. Results on carbofuran are not complete but also indicate tht chemically induced pH difference had little effect on the rate of disappearance. This was surprising when compared to differences in rate observed for similar pH differences in homogenous solutions, particularly for fonofos and carbofuran.

Analysis of water samples from the Holland Marsh from 1972-75 combined with pumping data showed that more organochlorine insecticides were pumped from the marsh in the spring when sediment-absorbed insecticides moved with the eroded soil during spring run-off. During summer when pumping from the marsh is intermittent depending on rainfall, the concentration of organophosphorus (OP) insecticides in the drainage ditch water exceeds that of the OC's and the water soluble OP's are pumped from the marsh in greater quantities than the OC's. Insecticide residues in fish from the marsh drainage ditch exceeded the 5 ppm tolerance for DDT but residues in fish from Cook's Bay, Lake Simcoe were minimal (<0.25 ppm DDT in 1975). In the laboratory the persistencesof 10 insecticides in water were examined over a 20-week period in natural and distilled water, sterile and non-sterile. Chlorpyrifos, dieldrin, and endrin were quite stable even in non-sterile water (>60% recovery after 20 weeks). p,p'-DDT, ethion, lindane, leptophos, and parathion were stable in sterile but not in non-sterile water indicating microbial degradation. Diazinon and mevinphos were not persistent in either the sterile or non-sterile waters. In other laboratory tests the persistence of 5 insecticides in water relative to pH was investigated. Ethion, parathion, chlorpyrifos, fonofos, and leptophos were incubated at room temperature in sterile aqueous phosphate buffers over the pH range 4.2 to 8.0 for 20 weeks. All showed an effect of pH on the hydrolysis rate which was greater for chlorpyrifos and leptophos. Chlorpyrifos was hydrolyzed the most rapidly over the entire pH range while leptophos showed the greatest increase in rate in going from acid to neutral to alkaline medium.

Air sampling for insecticide residues in the middle of the Holland Marsh during 1975 gave maximum concentrations of diazinon, malathion, leptophos, and DDT of 550, 30, 2, and 1 nanogram/cubic meter of air. For diazinon 550 ng/m^3 would represent an average human daily intake of about 5 micrograms. Recovery experiments indicated that the high volume air samplers used are inefficient, and the values reported here probably represent minimum levels.

18. Stephenson, G. R. - Methods to reduce herbicidal drift in roadside spraying.

Nalco-Trol, a polyvinyl polymer and Bivert TDN were evaluated for reducing spray drift in roadside spraying in 1975. Treatments were applied under normal field conditions for spraying. Spray drift was trapped with a grid consisting of petri dishes on a network of 12 ft poles inside and outside of the target area. Spray deposition was analyzed by examining the petri dishes under U.V. light for deposits of fluorescene which had been added as a tracer and by cucumber root inhibition bioassay for the herbicide (picloram + 2,4-D) applied in the spray.

In 1976 it was not possible to repeat tests with Bivert TDN due to a lack of interest on the part of the company. However, Nalco-Trol was examined again using the same sprayer as in 1975. It was also evaluated for reducing spray drift in applications to field crops with a field crop sprayer.

In another study, Nalco-Trol was compared with two different formulations of Norbak for reducing spray drift with the Ministry of Transport and Communications vehicle for spraying provincial highways.

As in 1975, Nalco-Trol again proved to be effective for reducing spray drift. This was evident with both fluorescene tracer and bioassay assessment of spray deposits.

Spray drift was also reduced in field crop spraying with Nalco-Trol. However, with the smaller nozzles, Nalco-Trol appeared to reduce the angle of spray leaving the nozzle, thus preventing normal overlap of spray for uniform coverage.

Remarkable results were obtained in the tests with the Ministry of Transport and Communications roadside spraying vehicle. With a water spray through OC nozzles, at a 13 mph vehicle speed, significant drift was detected to the limits of the grid 140 ft from the roadside. With the two Norbak formulations only trace deposits of spray were detected outside the target area. With Nalco-Trol, drift was reduced significantly but significant drift was intercepted as far as 15 ft from the target area.

19. Svec, H. J., Chapman, R. A., and Harris, C. R. - Control of cutworms attacking agricultural crops in southwestern Ontario.

This study was initiated early in 1977. Progress will be reported in the 1977-78 Research Report.

APPENDIX IV. Publications, theses, and papers submitted to scientific conferences relating to the Ontario Pesticides Advisory Committee Research Programs, April 1, 1976 - March 31, 1977

Birmingham, B. C. and Colman, B. 1977. The effect of two organophosphate insecticides on the growth of freshwater algae. Canadian Journal of Botany, Volume 55, Number 11 - Pages 1453-1456

Brown, J. R., Stopps, G. J., Chai, S. C., Chow, L. W. Human blood cholinesterase activity - Holland Marsh, Ontario, 1976. International Congress on Toxicology, Toronto, Ontario, 1977 Bulletin of Environmental Contamination and Toxicology. In Press (1977).

Butcher, J. E., Boyer, M. G. and Fowle, C. D. Some changes in pond chemistry and photosympathetic activity following treatment with increasing concentrations of chlorpyrifos. Bulletin Environmental Contamination and Toxicology, In Press (1977).

Chiba, M. A rapid spectrophotometric method for the simultaneous determination of intact benomyl and its degradation product, methyl 2-benzimidazolecarbamate (MBC), in organic solvents and water. J. Agric. Food Chem. In Press (1977).

Chiba, M. Effects of temperature on the equilibrium of benomyl, and its degradation products methyl 2-benzimidazolecarbamate and n-butyl isocyanate in benzene and chloroform. Bulletin Environmental Contamination and Toxicology. In Press (1977).

Harcourt, D. G., Guppy, J. C., and Ellis, C. R. Establishment and spread of tetrastichus julis (Hymenoptera: Eulophidae), a parasitoid of the cereal leaf beetle in Ontario. Canadian Entomologist 109: 473-476 (1977).

Hall, R. Subterranean mycoflora of white beans in Ontario. Proc. Can. Phytopath - Sec. 43: 29 (1976).

Hughes, D. N. and Fowle, C. D.* The effects of three organophosphorous insecticides on zoo-plankton and other invertebrates in natural and artificial ponds. Master's thesis presented to the Faculty of Graduate Studies, York University (1977).

Inculet, I. I., Kelly, C. B., Castle, G. S. P. Electrostatic application of pesticides in orchards by means of a narrow jet of particles. Proceedings of the Eleventh Annual Meeting of the Industry Applications Society of the Institute of Electrical and Electronics Engineers, Chicago, 1976.

Kinoshita, G. B., Harris, C. R. and McEwen, F. L.* Biology and Control of phyllotreta cruciferae (Goeze) (coleoptera:chrysomelidae) in south-western Ontario. Ph.D. thesis presented to the Faculty of Graduate Studies, University of Western Ontario (1976).

Langenberg, W. J., Sutton, J. C., and Gillespie, T. J. Relation of weather variables and periodicities of airborne spores of Alternaria dauci. Phytopathology. In Press (1977).

Laing, J. E. and Reid, J. A. E. Developmental threshold and degree days to adult emergence for overwintering pupae of the apple maggot Rhagoletis pomonella (Walsh) collected in Ontario. Proceedings of the Entomological Society of Ontario. In Press (1977).

Morgan, H. G. and Kaushik, N. K.* Sublethal effects of diazinon on stream invertebrates. Ph.D. thesis presented to the Faculty of Graduate Studies, University of Guelph (1977).

Stephenson, G. R., Pelly, E., Desat, P. D. and Curtis, L. R. Evaluation of Nalco-Trol and Bivert TDN for reducing herbicidal drift in roadside spraying. WSSA Abstracts, No. 116, p. 59 (1977).

Swanton, C. J. and Gillespie, T. J.* Influence of Environmental Factors on Development and Control of Botrytis Leaf Blight of Onions. Master's thesis presented to the Faculty of Graduate Studies, University of Guelph (1977).

* Principal Investigator and Supervisor of Graduate Student